DNV·GL

RULES FOR CLASSIFICATION

Ships

Edition October 2015

Part 6 Additional class notations

Chapter 9 Survey requirements

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FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

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CHANGES – CURRENT

This is a new document.

The rules enter into force 1 January 2016.

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SECTION 1 SHIPS BUILT FOR IN-WATER SURVEY OF THE SHIP'S BOTTOM AND RELATED ITEMS - BIS

1 General

1.1 Introduction

The additional class notation **BIS** applies to vessel's which has been prepared for in-water survey of the vessel's outside, which includes the openings in sides and bottom below the deepest load water line, bottom plugs, echo sounders and other underwater equipment.

1.2 Scope

The rules in this section give requirements for the markings of vessel's sides and bottom, rudder bearings, and survey requirements for tail shaft(s) and thruster(s).

1.3 Application

The additional class notation **BIS** indicates that the vessel is prepared for in-water survey. The conditions under which in-water survey is allowed are given in Pt.7 Ch.1 Sec.1. Means should be provided to enable the diver to confirm that the sea suction openings are clear. Hinged sea suction grids will facilitate this operation, preferably with revolving weight balance or with a counter weight, and secured with fitting while the ship is afloat.

1.4 Class notations

1.4.1 BIS

Ships built in compliance with the requirements as specified in Table 1 will be assigned the additional notation related to survey arrangement:

Table 1 Additional class notation related to survey arrangement - BIS

Class Notation	*Qualifier*	*Purpose*	*Application*
BIS Mandatory: No Design requirements: [3] FiS requirements: N.A.	<None>	Built for in-water survey of the ship’s bottom and related items	

2 Procedural requirements

2.1 Documentation requirements

2.1.1 BIS

Documentation shall be submitted as required by Table 2.

Table 2 Documentation requirements forclass notation BIS

Object	*Documentation type*	*Additional description*	*Info*
Hull structure	Z030 – Arrangement plan	Openings in sides and bottom below the deepest load waterline, bottom plugs, echo sounders and other underwater equipment.	FI
Bottom survey marks	Z030 – Arrangement plan	Markings for identification of tanks on sides and bottom.	AP
Rudder arrangements	Z250 – Procedure	Measurement of bearing clearances.	FI
Impressed current system	Z030 – Arrangement plan		FI
AP = For approval; FI = For information ACO = As carried out; L = Local handling; R = On request; TA = Covered by type approval; VS = Vessel specific			

3 Design requirements

3.1 Onboard documentation

The documentation required by Table 2 shall be available onboard.

3.2 Markings of ship's sides and bottom

3.2.1 The underwater body shall be marked in such a way that the surveyor can identify the location of any observations made. Transverse and longitudinal reference lines of approximate length 300 mm and width 25 mm shall be applied as marking. The marks shall be made permanent welding or similar and painted in a contrasting colour.

Marking shall normally be placed as follows:

— At flat bottom in way of intersections of tank bulkheads or watertight floors and girders.
— At ship's sides in way of the positions of transverse bulkheads (the marking need not be extended more than 1 m above bilge plating).
— The intersection between tank top and watertight floors in way of ship's sides.
— All openings for sea suctions and discharge.
— Letter and number codes shall be applied on the shell for identification of tanks, sea suctions and discharges.

3.3 Rudder

3.3.1 Bearing materials shall be stainless steel, bronze or an approved type of synthetic material and shall satisfy the requirements in Pt.3 Ch.14 Sec.1.

3.3.2 For water lubricated bearings, arrangements shall be made for measuring of rudder stock and pintle clearances while the ship is afloat.

3.4 Tailshaft

3.4.1 The tailshaft shall be designed to minimum 5 years survey interval, ref. Pt.7 Ch.1 Sec.1 [1].

3.5 Thrusters

3.5.1 Thrusters shall have 5 year survey interval or alternatively the reduced scope survey, as required in Pt.7 Ch.1 Sec.5 [4] /Pt.7 Ch.1 Sec.5 [5], shall be possible while the ship is afloat.

SECTION 2 ENHANCED SURVEY PROGRAM - ESP

1 General

1.1 Introduction

The additional class notation **ESP** applies to ships covered by SOLAS Ch. XI-1 - "Special measures to enhance maritime safety" and refer to Pt.7 Ch.1. The notation is mandatory for these ship types and gives requirements and guidelines for an enhanced survey programme.

1.2 Scope

The rules in this section give requirements for the different ship types, which includes a description of the types of construction, for which the additional class notation **ESP** is mandatory.

1.3 Application

The additional class notation **ESP** is applicable for oil tankers, bulk carriers, ore carriers and chemical tankers, as covered by SOLAS Ch. XI-1 - "Special measures to enhance maritime safety". Further details about the requirements and guidelines for **ESP** are described in Pt.7 Ch.1.

2 ESP ships

2.1 Oil tankers

2.1.1 The notation "**ESP**" shall be assigned to seagoing self-propelled ships which are constructed generally with integral tanks and intended primarily to carry oil in bulk.

2.2 Bulk Carriers

2.2.1 The notation "**ESP**" shall be assigned to seagoing self-propelled ships which are constructed generally with single deck, double bottom, hopper side tanks and topside tanks, and with single or double side skin construction in cargo length area, and intended primarily to carry dry cargoes in bulk. Typical midship sections are given in Figure 1.

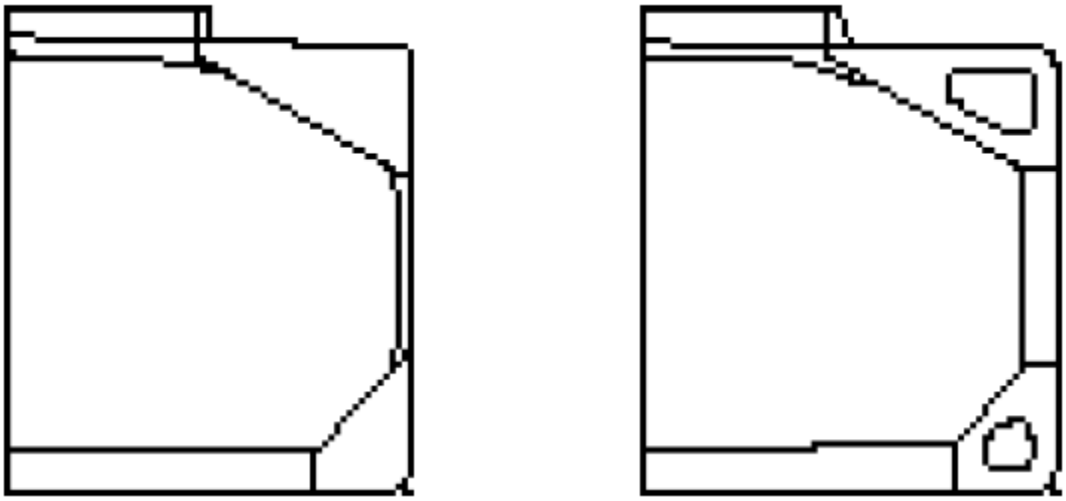

Figure 1 Typical midship sections

2.3 Ore Carriers

2.3.1 The notation "**ESP**" shall be assigned to seagoing self-propelled ships which are constructed generally with single deck, two longitudinal bulkheads and a double bottom throughout the cargo length area, and intended primarily to carry ore cargoes in the centre holds only. Typical midship sections are given in Figure 2.

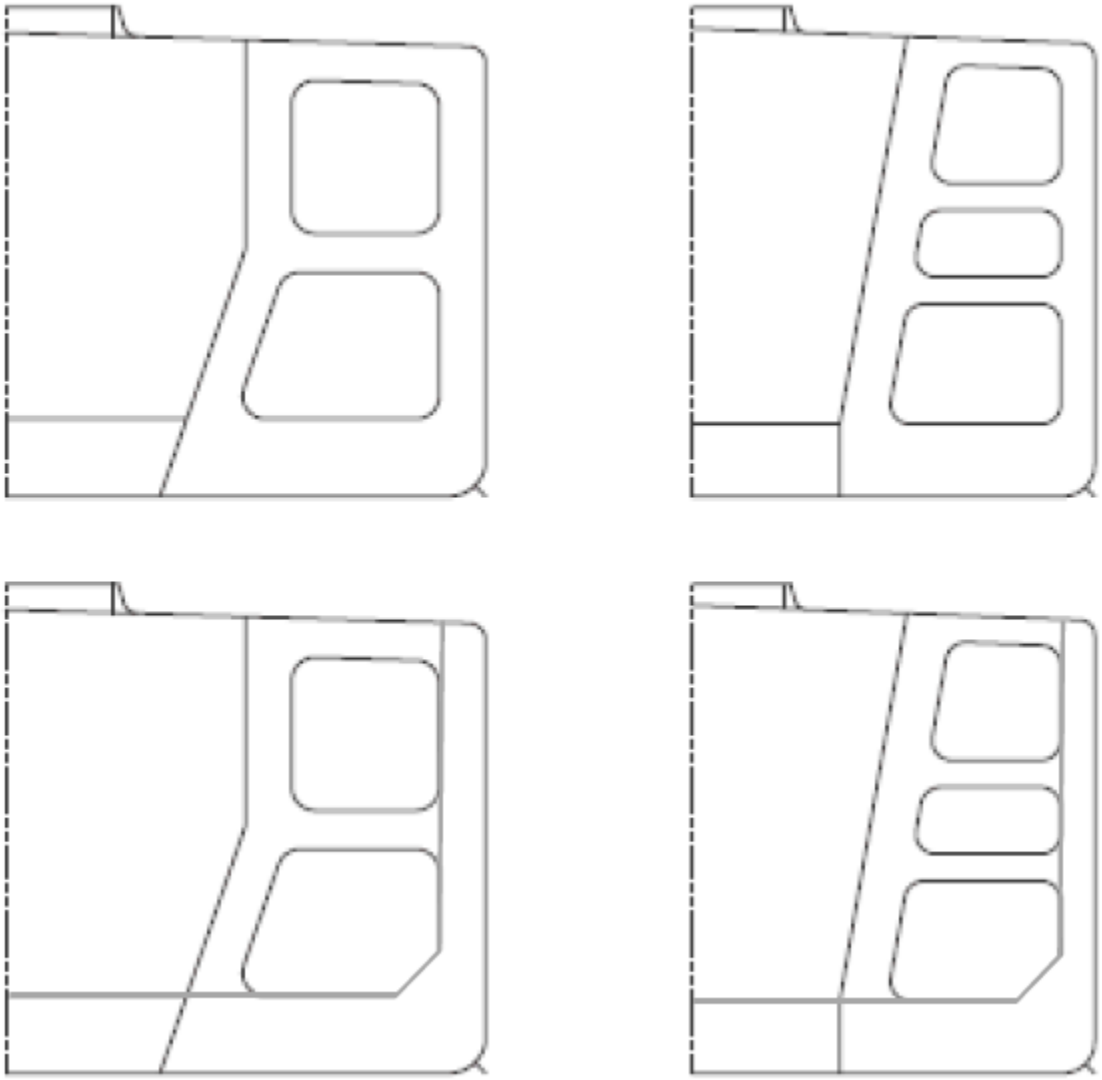

Figure 2 Typical midship sections

2.4 Chemical tankers

2.4.1 The notation "**ESP**" shall be assigned to seagoing self-propelled ships which are constructed generally with integral tanks, and intended primarily to carry chemicals in bulk. This type notation shall be assigned to tankers of both single and double hull construction, as well as tankers with alternative structural arrangements.

SECTION 3 HULL LIFE CYCLE PROGRAMME - HLP

1 General

1.1 Introduction

The additional class notation **HLP** allows determining of the remaining strength dependent on the actual measured condition of the structure.

1.2 Scope

The renewal thickness is calculated based on the corrosion measurements and based on the rules in Pt.3, Pt.5 and Pt.6 - Additional class notations .

1.3 Application

The additional class notation **HLP** is applicable for ships, where 3D hull structural model for the performance and documentation of thickness measurements with the Pegasus program is available in electronic form. The thickness measurements captured using Pegasus and this model, can then be used to determine the actual strength of the ship's hull.

1.4 Procedure

1.4.1 The renewal thickness is calculated based on the corrosion measurements and based on the rules in Pt.3, Pt.5 and Pt.6 - Additional class notations .

SECTION 4 HULL MONITORING SYSTEMS - HMON

1 General

1.1 Introduction

The additional class notation **HMON** applies for ships where a system for monitoring of the hull response, sea state and operational parameters is arranged. The system shall give warning when stress levels and the frequency and magnitude of ship accelerations approach levels that require corrective action. The owner shall decide how the hull monitoring system should be configured, i.e. which features to be included and how the measured and processed data shall be used.

1.2 Scope

The scope of the additional class notation **HMON** is to add an additional level of safety related to the maintenance of the ship. The information acquired by the system can be utilised in planning of the ship's maintenance.

The monitoring system is intended as an aid to the Master's judgement and not as a substitute for it. Accordingly, any failure of the system does not detract from the Master's absolute responsibility to take correct action in operating the ship. Sensors included in the system shall be approved or type approved by the Society. A sensor that has a MED type approval by a notified body will generally be accepted based upon presentation of the certificate; however accuracy requirements may need special consideration beyond normal MED approval.

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Further, electrical equipment and installation in hazardous areas shall be in accordance with Pt.4 Ch.8 and applicable class notation(s) for Special Service and Type. All equipment located at the navigation bridge shall be type tested in accordance with Pt.4 Ch.9 for EMC, emission only. In addition all equipment shall be fitted with dimmers and have displays which do not interfere undue with the night vision of the officer of the watch.

1.3 Application

A ship equipped with a hull monitoring system designed, manufactured and tested in compliance with the requirements in this section may be assigned the additional class notation **HMON** where within the brackets there will be qualifiers specifying what type of sensors and or features are included in the system and digits specifying the number of each type of the sensors and or features. The qualifiers, specifying the type of sensors/features, are given in Table 1:

Table 1 Qualifiers

Term	*Description*
A	Sensor monitoring acceleration along one axis.

Term	Description
B	Statistical back-up and trigged time series to be sent annually to the Society.
C	Online link to loading computer which is continuously up-dating the loading condition.
D	Online data link between hull monitoring system on board to office ashore. The link shall make it possible to operate the system from an onshore computer, perform maintenance and transfer data.
E	Sensor monitoring the propulsion shaft(s) output/rpm.
G	Sensor monitoring global hull strain.
H	Sensor monitoring the liquid motion pressures in tanks (sloshing).
L	Sensor monitoring local hull strain.
M	Device for monitoring of hull rigid body motions (six degrees of freedom).
O	
P	Sensor monitoring the sea pressure acting on the hull.
S	Device for monitoring the sea-state.
T	Sensor monitoring the temperature.
W	Wind sensor for wind speed and wind heading.

The types and number of sensors shall be selected on basis of owner requirements. The class notation will be assigned on the basis of plan approval, certification of equipment, if required, and on board survey and testing.

1.4 Definitions

1.4.1 Terms

The definitions are described in Table 2:

Table 2 Definitions

Term	Definition
Course	course is the horizontal direction of the vessel in which the vessel is sailing expressed as angular distance from the true north.
Heading	heading is the horizontal direction of the vessel in which the vessel's bow is pointing expressed as angular distance from the true north.
Display	display means by which a device presents visual information to the operator.
Data Processing Unit(s)	Data Processing Unit(s) refers to device(s) designed to process data according to defined algorithms (e.g. signal conditioning units, amplifiers, computers, display units).
Position fixing system	position fixing system (e.g. GPS) is a satellite system intended to provide highly accurate position, speed over ground and course over ground on a global basis.
Speed log	speed log is an instrument for measuring the speed and/or distance travelled by a vessel.
Position	position is the description of a place by its global co-ordinates i.e. latitude and longitude.
Response	response is a general term that includes all types of reactions (e. g. strain, motion, acceleration etc.) of the hull due to an applied load.

Term	*Definition*
RPM	revolution per minute.
Sensor	sensor is a device which measures a physical quantity as strain, acceleration, pressure etc.
Slamming	slamming is the result of the interaction (relative velocity) between ship and waves leading to sudden impact on the ship structure .
Sloshing	sloshing is the result of the interaction (relative velocity) between liquid in a tank and the tank structure leading to impact on the structure.
Speed	speed is the distance per unit time covered by the movement of the vessel.
Strain	strain is the relative dimensional elongation and/or shortening caused by an applied force.
Stress	stress is assumed the stress is proportional to strain and conforms to Hooke's law.
Torque	torque is the torsional moment on the rotating propulsion shaft(s).
Wave condition	wave condition is referring to a two-dimensional frequency spectrum of the sea-state. Statistical parameters such as wave height, wave period and dominant wave direction are derived from this frequency spectrum.
Wind condition	wind condition is the velocity, i.e. average speed and dominant direction of the wind relative to the longitudinal ship axis.

1.5 Documentation requirements

1.5.1 The basic documentation requirements for control and monitoring systems are given in Pt.4 Ch.9 Sec.1. The additional documentation required for **HMON** compliance for a hull monitoring system is listed in Table 1:

For installation in hazardous areas, documentation according to Pt.4 Ch.8 Sec.11 shall be submitted for approval.

1.5.2 Documentation shall be submitted as required byTable 3.

Table 3 Documentation requirements

Object	*Documentation type*	*Additional description*	*Info*
Hull monitoring system	I010 - Control system philosophy	Purpose, monitoring philosophy and size requirements for placement of processing and interface units including dimension drawings for components.	FI
	I020 - Control system functional description	Including data processing.	AP
	I030 - System block diagram (topology)	Including equipment located in hazardous areas, termination drawings and loop diagrams.	AP
	I040 - User interface documentation		FI
	I050 - Power supply arrangement		FI
	I110 - List of controlled and monitored points	Sensor list with accurate positions.	AP

Object	*Documentation type*	*Additional description*	*Info*
	I140 - Software quality plan	Modification of hull monitoring system (e.g. change of data in configuration file, removal of sensors, adding sensors, replacing sensors, changing sensor locations, maintenance).	FI
	I220 - Interface description	Interface specifications of sensors.	FI
	I280 - Reference data	Configuration file with specification of data used as input to the software (e.g. S-N curve, stress concentration factors, target fatigue life, filter frequencies and alarm settings).	AP
	Z030 - Arrangement plan	Sensors (I110 including sketch of layout of components).	AP
	Z090 - Equipment list		FI
	Z110 - Data sheet	Including sensor data with ranges and accuracy.	FI
	Z252 - Test procedure at manufacturer		AP
	Z262 - Report from test at manufacturer		AP
	Z253 - Test procedure for quay or sea trial		FI
	Z263 - Report from quay and sea trial	Test report including "zero" setting. Data format description for stored data. Channel list for sensors including sensor names with clarification. Installation report. Sensor calibration certificates.	FI
	Z161 - Operation manual	User manual (reference to I040 for main functions).	AP
	Z162 - Installation manual	Including yard work checklist.	AP
	Z163 - Maintenance manual	Including maintenance plan and replacement of hardware and update of software. Calibration procedure. Backup procedure of stored data (statistics, triggered time series, on board selected time series).	AP
AP = For approval; FI = For information ACO = As carried out; L = Local handling; R = On request; TA = Covered by type approval; VS = Vessel specific			

1.5.3 For general requirements for documentation, including definition of the info codes, see Pt.1 Ch.3 Sec.2.

1.5.4 For a full definition of the documentation types, see Pt.1 Ch.3 Sec.3.

1.5.5 Maintenance and instruction manuals

Instruction manuals shall be kept on board. The manuals shall contain necessary instructions on:

— operation

— calibration of sensors and system
— identification of faults
— repairs
— systematic maintenance and function testing
— interpretation of measuring results.

The plan for systematic maintenance and function testing shall show how components and systems shall be tested and what shall be observed during the tests.

A log for maintenance and calibration of the hull monitoring system shall be kept on board.

The maintenance log and all relevant certificates shall be kept together within the manuals.

2 Component requirements

2.1 Component requirements

2.1.1 General

All components and systems shall be designed and installed in accordance with the requirements given in Pt.4 Ch.9 Sec.5

All components shall be replaceable and designed for easy maintenance.

Electrical equipment and installation in hazardous areas shall be in accordance with Pt.4 Ch.8 and applicable class notation(s) for Special Service and Type.

All equipment located at the navigation bridge shall be type tested in accordance with Pt.4 Ch.9 for EMC, emission only. In addition all equipment shall be fitted with dimmers and have displays which do not interfere undue with the night vision of the officer of the watch.

2.2 Sensors

2.2.1 General

The sensor shall be designed in such way that the influence of changes of quantities other than the quantity that it is intended to be measured is minimised, i.e. strain sensors shall be designed in such way that the measured value is not influenced by changes in temperature.

Guidance note:

Any strain signal measured by a sensor, which is mounted on a piece of the actual material with free-free boundary conditions, during temperature changes shall be considered a measurement error and should ideally be zero.

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The sensors shall be mounted in such way that they only measure the quantity intended, i.e. sensors for measuring global hull strain shall be mounted in such way that influence of local strain is minimised.

Sensors that are part of other systems, i.e. the bridge navigation system, loading computer and engine control system, can be utilised in the hull monitoring system. Connections to such sensors shall be made in such way that they do not influence performance of the other systems. Failure of the hull monitoring system shall not influence the performance of other systems.

2.2.2 Amplitude ranges

Accelerations shall be measured over a range of -20m/s^2 to +20m/s^2. The measurement uncertainty of the acceleration shall be less than 2% of the measured value, or 0.10m/s^2, whichever is the greater.

The rigid body ship motions shall be measured by a device with integrated sensors, giving the six degrees of freedom (three translations and three rotations). The translations (accelerations) shall be measured over a range of -20 m/s^2 to +20 m/s^2. The angles shall be measured over a range of -90º to +90º, -45º to +45º and -180º to +180º, for the roll pitch and yaw motions, respectively. The measurement uncertainty shall be less than 2% of the measured value, or 0.10 m/s^2 for translations and 0.5º for angles, whichever the greater.

The sea pressure acting on the hull shall be measured over a range of 0 N/mm^2 (atmospheric pressure) to 2 N/mm^2. The measurement uncertainty of the pressure shall be less than 2% of the measured value, or 0.01 N/mm^2, whichever the greater.

The liquid motion pressures in tanks (sloshing) shall be measured over a range of 0N/mm^2 (atmospheric pressure) to 4N/mm^2. The measurement uncertainty of the pressure shall be less than 4% of the measured value, or 0.02N/mm^2, whichever the greater.

The structural strain shall be measured in a range related to the yielding strain of the material. The measurement uncertainty shall be less than 3% of the measured value or 20 micro strain, whichever is the greater. For ships made of steel or aluminium, a range from -2000 micro strain to +2000 micro strain can be assumed. For ships constructed using special material qualities or different types of materials, i.e. composite materials, the strain range shall be approved by the Society on a case by case basis.

2.2.3 Frequency ranges

The sensors installations designed for low frequency responses, i. e. motions and wave loading shall record the physical quantities within the specified uncertainties within the frequency range 0.01 to 3Hz.

Installations designed to measure slamming responses shall record the physical quantity within the specified uncertainties in the frequency range 5 to 100Hz.

Installations designed to measure sloshing responses shall record the physical quantity within the specified uncertainties in the frequency range 30 to 1200Hz.

The data processing unit shall be capable of handling information supplied by all sensors including navigational instruments at the actual transfer rate.

Guidance note:

Navigation system (or dedicated units) commonly uses NMEA format for information transfer.

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The information from the sea-state parameters shall at least be up-dated and submitted every 10 minutes.

2.3 Signal conditioning units

2.3.1 General

The signal conditioning units shall be matched to the connected sensor.

The signals from analogue sensors shall be low-pass filtered prior to digitising to avoid signal noise. The filters shall be matched to the frequency range for the different sensors. See [2.2.3].

2.3.2 Sampling frequency

The sensors installations designed for low frequency responses, i. e. motions and wave loading shall be digitised with at least 20Hz.

Installations designed to measure slamming responses shall be digitised with at least 500Hz.

Installations designed to measure sloshing responses in tanks shall be digitised with at least 3kHz.

3 System design

3.1 System requirements

3.1.1 General

The mandatory and the recommended minimum of parameters to be measured for the different ship types are given in Table 4.

In the case when signals from two or more sensors are transmitted through the same conductor(s), the measuring signal from each individual sensor shall be separated in such way that each sensor can utilise the full measuring range without interfering with the signals from other sensors.

All electrical components that are exclusively used in the hull monitoring system, i.e. not sensors included in the navigation system, shall be powered through an UPS (un-interruptible power supply). In case of mains power failure, the UPS shall have sufficient capacity to maintain normal operation of the hull monitoring system for at least 10 minutes. The hull monitoring system shall automatically shut down in a controlled manner within the UPS power reserve time.

The hull monitoring system shall automatically re-start at return of mains power. The default display shall appear.

The hull monitoring system shall be designed in such way that possible influence of settling time of the hardware and the software (e.g. software filters) on the measured data shall be within the tolerance limits.

The system shall include a computer with sufficient capacity to perform the tasks required, e.g. process the sensor signals, display the information required on a screen, give audio alarms and store the data.

In the case that the ship is equipped with a loading computer, the still water forces and moments shall be transferred to the hull monitoring system. The system shall use this information to calculate the bending stress at the global strain positions.

Guidance note:

It is recommended to design the loading computer software to calculate the bending moment at the positions where the global strain sensors are located. If this is not the case, linear interpolation of the moment can be used to estimate the moment at the sensor position.

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The system shall be designed to give visual and audible alarm for at least the following incidents:

— power failure
— unreasonable values indicating sensor failure
— signal from a sensor exceeding the alarm threshold value.

The programs and data held in the data recording system shall be protected from corruption by loss of power.

The user interface (display, keyboard and audible alarms) shall be installed on the bridge at a position close to, or integrated in the bridge navigation system.

A data storage device suitable for saving time series and statistical information shall be used.

The system shall have minimum data storage capacity and functionality as specified in [3.5].

The hull monitoring system shall be configurable. The configuration shall include all settings that are relevant for a specific installation. Such settings will typically be calibration factors, sensors threshold values, filter cut-off frequencies, statistical calculations that are selected for the different sensors etc. The configuration shall be included in the manual.

3.2 Primary elements

3.2.1 General

Sensors shall be protected against mechanical damage, humidity (water), exposure to excessive high or low temperatures and damage from local vibration sources.

In the case that the ship already has installed a sensor for monitoring of a certain parameter, it is not required to install a separate sensor for the hull monitoring system.

Guidance note:

If the ship has installed navigation EPFS (Electronic Position Fixing System), the HMON system may be connected to the navigation EPFS. When navigational sensors are used, the listener port on the hull monitoring system shall be in accordance with IEC 61162 in order to protect the talker (EPFS) from failure in the hull monitoring system.

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The system shall have output port for providing Voyage Data Recorder with all IMO mandatory information (IMO Res. A.861(20)) from the system. The port should be compliant with IEC 61162.

3.2.2 Strain gauges

The position of the strain gauges shall take account of the structural configuration of the ship and its mode of operation.

Guidance note:

The strain gauges for measuring vertical hull girder bending should be located in such a way that the system monitors global strain (port + starboard) in the deck structure as near as practicable to amidships and in addition at the quarterly lengths (± L/4 from mid ship for vessels with L > 180? metres). See Table 4.

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3.2.3 Accelerometers

Dynamical amplification, in the frequency range of interest, of the mounting fixture shall be minimized.

3.2.4 Position indicator

A position fixing system (e.g. GPS) shall be installed.

Guidance note:

If the ship has a navigation position fixing system, the position may be taken from the navigation position fixing system.

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3.2.5 Wave sensors

An arrangement to monitor the wave condition shall be installed. The system shall produce a two-dimensional spectrum (wave frequency and relative direction between wave and ship heading). Based on the spectrum, significant wave height, main wave direction and main wave period shall be derived.

Guidance note:

Systems that use the signal from the navigation radar shall have a sign that instruct the navigator to put the radar into correct mode for wave monitoring when the radar is not in use for navigation purposes.

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3.2.6 Wind sensors

An anemometer giving speed and dominant direction of the wind shall be used. The position of the sensor above the scantling draft shall be provided in the configuration file in [1.5.1].

Guidance note:

The instrument should correct the displayed values with respect to ship speed over ground and heading. If not, the configuration file shall state that correction to the wind measurements has not been done.

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3.2.7 Speed monitoring

The speed of the vessel may be taken from the position fixing system (e.g. GPS) or the speed log.

Guidance note:

The position fixing system shows the speed over ground. The speed log normally shows the speed through water. The difference may be taken as current. If the speed log shows speed over ground, the configuration file shall state that the speed log shows speed over ground.

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3.2.8 Course monitoring

The course of the vessel may be taken from the position fixing system or the gyro compass.

Guidance note:

The position fixing system measures course over ground, while the gyro compass measures the heading. The course over ground and heading may differ due to sea, current and wind conditions.

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3.2.9 Hull rigid body motions

The rigid body motions shall be referred to a position close to the centre of gravity in full load condition. The position taken as origin for the shall be specified in the configuration file as well as the position of the motion reference unit.

Guidance note:

When it is inconvenient to install the motion sensor close to the centre of gravity, the sensor may be mounted as close as possible to the centre of gravity and the motions in the reference position may be computed by software based on the motions measured and the distance from sensor position to the reference position.

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3.2.10 Loads due to transient sea pressure (slamming)

Loads due to transient sea pressure (slamming) shall be measured in terms of normal stress (strain) at the structure on which the pressure is acting, e.g. the pressure loads shall be measured as normal stress on longitudinal(s) or plating.

The loads may alternative be measured in terms of sea pressure using pressure transducer(s) mounted through the hull.

Guidance note:

A pressure transducer mounted through the hull bottom plating in the bow area can given information about the distance from the water surface down to the ship bottom. Hence, a pressure transducer in this position may give an early warning on the possibility of bottom slamming.

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An accelerometer in the bow area may also be used as an indicator of slamming incidents.

Guidance note:

The maximum slamming pressure, with limited spacial distribution and short duration, depends on the ship design. The global response as acceleration may indicate that slamming occurs, but does not confirm the location. The number and locations of the slamming sensors should be carefully considered, e.g. by numerical calculations.

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3.2.11 Loads due to liquid motions in tanks (sloshing)

Loads due to liquid motions in tanks (sloshing) shall be measured in terms of stress (strain) in the structure on which the loads are acting.

The loads may alternatively be measured in terms of pressure using a pressure transducers mounted through the tank wall.

In tanks with insulation system and inner gas tight membrane (LNG tanks), the loads may alternatively be measured by a load cell mounted behind the membrane.

Guidance note:

The number and locations of sloshing sensors should be carefully considered, e.g. by numerical calculations. Using external strain sensors to measure pressures inside membrane tanks, the correlation factor between internal pressure and measured external strain shall be estimated and provided in the configuration file. The warning level needs careful considerations and shall be specified in the configuration file.

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3.2.12 Structural temperature

Temperature sensors installed on the supporting structure of cargo tanks containing cooled or heated cargo, shall at least have an operational range that covers the temperature of the cargo and the temperature in the structure when the cargo hold is empty.

Temperature sensors used for fire fighting vessel and related equipment shall cover the necessary temperature range and the warning level shall be specified in the configuration file.

3.3 Data processing

3.3.1 General

The parameters given in Table 4 shall be processed and made available for the hull monitoring display.

The measured signals shall be split into given time intervals for data processing. The results from the data processing for each time interval shall be stored. The time interval selected, TI, in minutes, shall be set during the initial configuration of the software and shall be stated in the configuration file

Guidance note:

The data on the screen shall be updated at intervals not longer than 5 minutes. In cases when an averaging period longer than 5 minutes is selected, the data processing should be performed at least every 5th minute on the latest data sequence corresponding to the selected processing period. Time intervals, TI, of 30 or 60 minutes are suitable for conventional ships and 10 minutes are suitable for high speed light crafts. Data for these time intervals shall be stored.

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The type of processing, each individual sensor signal is subjected to, shall be defined during the initial configuration of the system and shall be included in the configuration file.

Guidance note:

The different types of processing may not be relevant for all types of sensors (e.g. Rainflow counting may not be useful on an accelerometer signal). Hence, this aspect should be carefully considered during the configuration.

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3.3.2 Data filtering

The software shall include high-pass, low-pass and band-pass time domain digital filters. The cut-off frequency of the filters shall be configurable through the software and shall be stated in the configuration file

Guidance note:

It should be noted that filtering may not be relevant for all types of sensors or phenomena to be measured. Only in cases when relevant, filtering should be considered.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

The filters shall be designed to have a stop-band attenuation of at least 40 dB.

The filters shall be initiated at the start-up of the hull monitoring software, and be continuously active as long as the software is running during normal operation. The part of the filtered signal that is corrupted by the settling of the filter during start-up shall not be used in the subsequent data analyses.

The system shall have the capability to simultaneously perform filtering on all the measured time series of hull responses. The time series subjected to filtering shall be configurable through the software.

The system shall be able to put the time signal from all sensors measuring the ship responses through the following filtering processes, giving four different time series:

— no filtering (static value and both wave and vibrations responses are maintained)
— low-pass filtering (static value and the wave response is maintained)
— high-pass filtering (static value and low cycle temperature fluctuation are removed; the wave and vibration responses of the signal are maintained)
— high-pass filtering (only the vibration response is maintained).

Guidance note:

The following filter characteristics may be assumed for all sensors, except sensors dedicated for sloshing and slamming responses:

— the high-pass filter removing static value and low cycle fluctuations shall maintain the energy above 0.01 Hz
— the low-pass filter shall maintain the energy for frequencies below 0.3 Hz, and remove the energy for frequencies above 0.4 Hz
— the high-pass filter shall remove the energy for frequencies below 0.3 Hz, and maintain the energy for frequencies above 0.4 Hz.

For large ships with their lowest resonance frequency below 0.4Hz, special considerations of the frequency bands are necessary. Similarly, for high speed vessels with wave response at encounter frequencies above 0.3Hz, the frequency limited need to be specially considered.

For sensors dedicated to slamming measurements, the low frequency boundary is suggested to 5 Hz. For sensors dedicated to sloshing measurements, the low frequency boundary is suggested to 30 Hz.

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The software shall be able to display each of the four different time series.

The software shall be able to perform the data analyses described in [3.3.3] through [3.3.7] on each of the four different time series.

The software shall be able to utilise both the non-filtered signal and the signal where the static value and the low cycle fluctuations are removed in connection with Global Hull Stresses (see [3.3.7]) and Threshold Values and Alarms (see [3.3.8]). The choice shall be configurable through the software and shall be specified in the configuration file

3.3.3 Statistical calculations

The software shall be able to perform the statistical calculations on the time series described in [3.3.1] and [3.3.2]. The sensors selected for statistical calculations and statistical operation to be performed shall be configurable in the initial set-up of the software. The sensor list (channel list) shall be included in the configuration file.

The following statistical parameters shall be calculated for each of the selected ship response parameters:

— maximum value
— minimum value
— mean value
— standard deviation
— skewness
— kurtosis
— mean zero crossing period (or mean crossing up count)
— maximum peak to peak value
— number of observations used to calculate statistical parameters

For each of the ship responses, a histogram of all the peaks in the time history shall be established. The amplitude for each response shall be divided into pre-set intervals, and the number of peaks within each interval shall be counted. Hence, the histogram will contain the number of peak occurrences within each interval. The intervals shall be set during configuration of the software and listed in the configuration file

Guidance note:

The following intervals are suitable for the different types of ship responses:

— stress for steel ships 5N/mm^2
— stress for aluminium ships 2.5N/mm^2
— acceleration 0.1m/s^2
— pressure 0.05N/mm^2
— roll angle 2º
— pitch angle 0.5º
— heave translation 0.25m.

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Similar histograms of the ship responses as described for the peaks shall also be established for the troughs.

For transient phenomena, such as liquid impacts (slamming and sloshing), the integrated energy of each impact shall be calculated.

For transient phenomena, such as liquid impacts (slamming and sloshing), the rise time of each impact shall be calculated. The limits for the calculation shall be configurable.

Guidance note:

The rise time may be defined as the time it takes the impact to reach from 20% of peak value to 90% of peak value on the rising flank.

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3.3.4 Probability distribution and threshold value

Based on assumptions of statistical distribution of the parameters derived in [3.3.3], a curve for the probability of exceeding a certain value within a given time period shall be estimated. The time period shall be configurable through the software and listed in the configuration file

Based on the probability curve the probability of exceeding a predefined threshold value shall be found. The threshold value shall be configurable through the software and listed in the configuration file

3.3.5 Fatigue damage estimation from strain sensors

The fatigue damage of the structural elements equipped with strain sensors shall be estimated based on the measured time history.

Guidance note:

The method described in Classification Notes No. 30.7 (CN30.7) should be used.

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The fatigue rate, D_R, shall be estimated as the ratio of the measured fatigue damage, D_{TI}, and the budget damage per unit time, D_{BTI}. The time interval, TI in minutes, given in [3.3.1] and the target design fatigue life, T_{DF}, in years, shall be listed in the configuration file. The fatigue rate can be expressed as:

$$D_R = \frac{D_{TI}}{D_{BTI}} = \frac{D_{TI}}{(TI)/(T_{DF} \cdot 365.25 \cdot 24 \cdot 60)}$$

Guidance note:

The fatigue rate shall be shown on the display. Most of the time it will be less than 1.0. A suitable warning level can be taken as $4 \cdot T_{DF}$ for TI equal and more than 30 minutes and $8 \cdot T_{DF}$ for TI less than 30 minutes. E.g. being at a fatigue rate of 90 for one day, 3 months of fatigue budget has been spent.

The fatigue life can be estimated as the design fatigue life divided by the average fatigue rate over a long measurement period.

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The stress response histograms shall be established for each strain sensor using a cycle count method.

Guidance note:

The Rainflow Cycle Counting method (ASTM Standard E-1049) is recommended for establishing the stress response histograms. The following stress range intervals are suitable for the different types of ship:

- stress for steel ships $5N/mm^2$
- stress for aluminium ships $2.5N/mm^2$
- stress interval for other materials should be approved by the Society.

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The damage rate shall be estimated based on the stress response histogram, a relevant stress concentration factor (K-factor) and a S-N curve. The Society shall approve the K-factor and S-N curve to be applied for each strain sensor, which shall also be stated on the configuration file for each sensor

Guidance note:

S-N curve D (FAT90) in CN30.7 shall be used for welded details in combination with a relevant stress concentration factor. If no relevant detail has been specified, the K-factor can be taken as 1.32 (equivalent to FAT 68).

For non-welded details (i.e. base material) as free plate edge of hatch corners, S-N curve B to C2 may be relevant. If no specific surface condition has been specified, the S-N curve C can be used (no local K-factor should be applied for base material, i.e. K-factor = 1.0).

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The damage rate for each time interval shall be added together, resulting in accumulated damage rate for each strain sensor.

3.3.6 Loads due to transient sea pressure (slamming)

The number of transient peaks recorded by the sensor installed for the recording of slamming incidents exceeding the threshold level, shall be counted. The number count for a pre-defined time period shall be made available for the display. The threshold value and the time period shall be configurable through the software and stated in the configuration file

3.3.7 Hull stress

The hull girder strain (stress) may often be influenced by strain induced by temperature differences in the hull structure. This strain may be caused by temperature differences between the cargo and the environments or by partial heating of the hull structure due to sunshine. These effects may be reflected as low cycle variations of the measured strain. The strain due to these temperature differences is normally not to be included in the analyses performed by the hull monitoring system. The hull monitoring system shall have the capability to optionally remove the strain due to temperature differences in the hull girder (See [3.3.2]).

Guidance note:

It should be noted that in the cases that the strain due to temperature differences in the hull structure is removed, both the static value and the slow variations in the loading condition may also be influenced. Hence, variations due to shifting of ballast or water ingress in a cargo hold may also be influenced.

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The hull monitoring system shall have the capability to read the still water bending/torsion moments calculated by the loading computer (if applicable). This information could either be typed manually into the hull monitoring system through a keyboard or be transferred electronically by disk or data link. Based on this information, the hull monitoring system shall be capable of computing the strain (stress) due to the still water moments at each position where a sensor measuring global hull strain (stress) is positioned. In the case when the sensor position do not correspond to a section for where the still water moments is computed, a linear interpolation between the moments on each side of the sensor position may be applied.

Guidance note:

The information needed to convert the still water bending moments into strain (stress) by use of the section modulus at the measurement position will be supplied by the Society provided the vessel is classed or being classed by the Society. Otherwise, the section modulus should be supplied by the yard.

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The hull monitoring system shall have the following three options for each individual strain sensor, to be selected independently, for input to the statistical analyses and the alarm handler (see [3.3.3] to [3.3.8]). The option should be selected during the initial installation of the hull monitoring system and be stated in the configuration file:

- measured strain as recorded (including possible effects due to temperature differences in the hull structure)
- measured strain high-passed filtered in order to remove low cycle temperature effects
- measured strain high-passed filtered in order to remove low cycle temperature effects, and then have a strain offset added to the filtered strain signal, corresponding to the strain calculated by the loading computer at each sensor position.

All the stress measurements shall be put through the data analysed described in [3.3.3] to [3.3.5].

3.3.8 Threshold values and alarms

The hull monitoring software shall be designed to allow input of a minimum and a maximum threshold value for each sensor.

Guidance note:

For sensors that measure more than one quantity, the software shall be designed to allow threshold values for each quantity.

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The measured values shall be compared to the given threshold values for each sensor. In the case that the computed value exceeds 80% of a threshold value, an audible alarm shall be given. The cause of the alarm shall automatically appear at the hull monitoring screen.

Guidance note:

In the case that the mean value of the measured strain (stress) signal is replaced by the value based on the still water bending moment, the sum of the measured dynamic strain (stress) and the still water strain (stress) shall be compared to the threshold values (see [3.3.2])

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The cause of the alarm shall automatically be written to an alarm log that shall be stored on an electronic device. This alarm log shall be maintained for inspection on the hull monitoring display.

3.3.9 Trend predictions

The results from the calculations for each time interval as described in [3.3.3] through [3.3.7] shall be arranged in such way that a sequence of the latest data from each individual sensor can be displayed as a trend. The sequence shall at least include data from the last 4 hours for displacement ships and 30 minutes for high speed vessels.

A 4 hour data sequence from each individual sensors shall form the basis for a forecast trend prediction of the expected response from each individual sensor for at least the next hour. The measured and the predicted data shall be made available for the display. The method used for trend analysis should be specified in the configuration file.

Guidance note:

It is recognised that no extrapolation method is regarded perfect for all responses at any time. Extrapolation shall focus on the extreme value. Extrapolation by a Weibull fit shall be done as a minimum, but other methods should be used simultaneously to improve the reliability and include uncertainty bands.

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When the signal from an individual sensor exceeds 80 % of the specified threshold value for that sensor, the expected time to reach the threshold value shall be predicted based on trend analyses. The measured and the predicted data shall be made available for the display.

3.4 User interfaces

3.4.1 Display

The hull monitoring system shall have a display suitable for presentation of screen images that comply with Pt.4 Ch.9 Sec.6.

The system shall have screen images that clearly display all relevant information with respect to sensor positions, time series and processed data.

The system shall have at least screens that display the following information:

— clearly visualise the position of each individual sensor
— the status of each individual sensor, i.e. whether the sensor is operational or faulty
— real time information of the measured time series of each individual sensor
— signal level from each individual sensor compared to the threshold values
— current fatigue damage rate for each individual strain sensor
— trends of the statistical parameters for each individual sensor, including forecast predictions
— alarm status.

3.4.2 Audible alarm signal

The system shall have audible alarm signal that comply with Pt.4 Ch.9 Sec.3.

3.4.3 Keyboard

The system shall have a keyboard for manual input.

Guidance note:

Keyboard may be replaced by a touch screen.

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3.5 Data storage

3.5.1 General

The system shall have capacity to store at least five years of statistical data and 150 hours of time series from all sensors. For sensors dedicated to slamming and sloshing measurements, it is sufficient to store the time sequences where the transients are exceeding a given threshold value.

The system shall have the capability to back-up the recorded data on a medium suitable to be read on a personal computer (PC).

Guidance note:

The medium should be an electronic device without moving parts such as a USB memory stick.

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The data back-up file(s) shall include all the recorded data presented on a suitable format. The file(s) shall include sufficient information to clearly describe the content of the file(s).

Guidance note:

If the format is not a text format, the supplier should provide software or reference to free software for easy access to the data.

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For each time interval (see [3.3.1]), the system shall store the results from all the calculations for all the individual parameters recorded. The data shall be labelled with a time stamp (date and time) corresponding to the beginning of the time interval.

The system shall automatically store time series for all the measured parameters for a number of time intervals corresponding to at least a period of the last 12 hours of recording. Time series older than this period shall automatically be deleted from the storage device.

Guidance note:

This feature may be utilised as a simple voyage recorder. For slamming and sloshing it is sufficient to store the time sequences where the transients are exceeding a given threshold value.

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The system shall have the functionality, on request from the operator, to permanently store the 12 hour data. The system shall have the storage capacity to permanently store at least 12 such periods in addition to the 150 hours.

The system shall have output port for providing Voyage Data Recorder with all IMO mandatory information from the system. The port should be compliant with IEC 61162.

3.5.2 Back-up intervals

The first back-up shall be taken between one and two months after the installation. Thereafter, back-up shall be taken annually. A back-up log shall be maintained on board.

Guidance note:

The back-up should be sent to the superintendent of the vessel for storage as soon as practical possible after back-up is taken.

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Back-up medium for the first five years (six pieces) should be supplied with the system.

3.6 Extent of monitoring

3.6.1 General

The required minimum and the recommended minimum of sensors are shown in Table 4.

Guidance note:

IMO Recommendations for the Fitting of Hull Stress Monitoring Systems. (MSC/Circ.646)

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Table 4 Parameters to be monitored for the various types of vessels

A = Oil Carriers, OBO, Chemical Carriers, Liquefied Gas Carriers and Oil Production and Storage Vessels B = Bulk Carriers and Ore Carriers C = Container Vessels D = General Cargo Ships, Ro-Ro Vessels, Passenger Vessels, Cruise Vessels and other Vessels E = High Speed Light Craft			
Parameter	Required	Recommended	Remarks
Vertical accelerations at forward perpendicular (0.01L) at centre line		A, B, C, D	
Vertical, transverse and longitudinal acceleration at the centre line of each hull in the fore body (fore of forward perpendicular)	E		
Transverse acceleration in the 0.4L midship area		B, C, D	To monitor inertia loading on sensitive cargo. Sudden change in response may indicate irregular situations such as ingress of water in holds or at vehicle decks.
Vertical, transverse and longitudinal acceleration at the longitudinal centre of gravity (LCG)	E		
Vertical, transverse and longitudinal acceleration at the centre line of each hull aft body (aft of aft perpendicular)	E		
Motion reference unit		A, B, C, D	For motions, velocities and accelerations in six degrees of freedom. To be placed on bridge.
Global longitudinal stress amidships (port and starboard)	A, B, C, D[1], E[2]	E	[1] For vessels with hull girder sectional modulus < 1.5 Z_{rule}. [2] For vessels with length L> 50 m.
Global longitudinal stress at the quarter length L/4 from mid ship (port or starboard side)	A[3], B[3], C[3], D[4]	A, B, C, D	[3] For vessels with length L>180 m. [4] For vessels with hull girder sectional modulus < 1.5 Z_{rule} and with length L>180 m. 1)
Global transverse stress at transverse deck strip amidships	C		Stress indicating hatch opening distortion due to warping deformations. Sensors shall either be located at probable hot spot in hatch corner due to warping or on transverse deck strip capturing nominal stress. It is not meant to capture hot spot of longitudinal bending stress.

Longitudinal stress close to bottom (L/2) amidships (port and starboard)		B[5], C[6]	[5] Longitudinal stresses (L/2) amidships below the neutral axis, e.g. at bilge area. Only for ships with large openings in deck, for example open hatch carriers. [6] Longitudinal stresses (L/2) amidships below neutral axis, e.g. at bilge area.
Double bottom bending		C, B[7]	[7] For Bulk Carriers with class notation **BC(B), BC(A)** or **BC(B*)**, one strain sensor in inner bottom of each hold.
Bending/shear stress in pillar bulkheads		C[8]	[8] For vessels with operational limits with respect to draught with empty holds.
Global transverse stress in wet deck in centre between each hull		E[9]	[9] For multi-hull vessels with length L>50 m
Lateral loads at bottom near forward perpendicular		A, B, C, D,E[10]	[10] If slamming in the fore body may occur (ballast)
Lateral loads at side		A, B, C, D	
Lateral loads at the bow door		D[11]	[11] For Ro-Ro Vessels only. Measuring of relevant parameters, i.e. stresses or pressures.
Loading computer system	A, B, C, D		When installed.
Position, speed/course	A[12], B, C, D, E		[12] Not relevant for Oil Production and Storage Vessels.
Gyro compass	A, B	C, D	Heading deviating from course especially for slowly going vessels
Speed log	C	A, B, D	Speed through water (when installed)
Power output and revolutions of propulsor (s)	E, C	A, B, D	
Wave condition		A, B, C, D, E	
Wind condition	A, B, C, D, E		

4 Installation and testing

4.1 General

4.1.1 Certificates

All relevant certificates on the equipment included in the hull monitoring system shall be delivered.

4.1.2 Operations manual

An operations manual written in English and in a language appropriate for the ship's crew shall be on board.

4.1.3 Monitoring system

Information on how to interpolate the vertical hull girder bending moment values from the loading computer to the strain gauge positions shall be included in the computer programme of the system so that the loading instrument readings can be used for setting and checking the system.

Each strain gauge is initially to be set to a stress calculated in an agreed loading condition. This calculated stress shall be compatible with the output of the loading instrument and calculations made using the loading manual. The set-up shall not be carried out when dynamic stresses are present and shall be made when temperature effects are minimised and in absence of large gradients.

The initial readout of the sensor shall be checked against an agreed loading condition in calm water, with the attendance of a surveyor from the Society. In the event that the difference is greater than 5% of the approved value or $10N/mm^2$ occurs, whichever is the greater, the setup and subsequent checking shall be repeated.

The calibration shall be verified by a surveyor from the Society. Recommendations and calibration reports, signed by an authorised person shall be kept on board the ship.

4.2 Approval and testing procedure

4.2.1 General

The operation of the hull monitoring system shall be verified upon installation by a surveyor from the Society:

— witness that the relevant procedures for testing the system are carried out
— ensure that the recorded data is according to the requirement
— verify that the maintenance and calibration log is complying with the relevant procedures.

Guidance note:

All relevant procedures shall be kept together with the manuals as stated in [1.1.4].

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SECTION 5 TAILSHAFT MONITORING - TMON

1 General

1.1 Introduction

The additional class notation **TMON** applies for ships having a system for condition monitoring of the ship's tailshaft and stern tube bearing, including its lubrication. The additional class notation **TMON** ensures that a monitoring system for monitoring the temperature of the tailshaft and stern tube bearing, including its lubrication is in place; hence increasing the safety level by getting an alarm when the temperature is increasing towards a critical level.

1.2 Scope

The scope of the additional class notation **TMON** adds an additional level of safety related to the tailshaft and stern tube bearing, including its lubrication by monitoring the temperature of this equipment. This section provides requirements to the arrangement and the facilities necessary to monitor the condition of the tail shaft, stern tube bearing and its lubrication. The scope includes an initial survey and a continuous recording of parameters under the responsibility of the ship's Chief Engineer as required in Pt.7 Ch.1 Sec.6.

1.3 Application

Ships constructed in accordance with the requirements in this section and complies with the requirements in Pt.7 Ch.1 Sec.6 may be assigned the additional class notation **TMON**.

1.4 Documentation requirements

1.4.1 Documentation shall be submitted as required by Table 1.

Table 1 Documentation requirements

Object	*Documentation type*	*Additional description*	*Info*
Propeller shaft bearing	Z030 - Arrangement plan	Position of aft stern tube bearing temperature sensors	AP
	S010 – Piping diagram (PD)	Lubrication system for stern tube bearing including oil system for sealings. Identification of sampling point	FI
	Z250 – Procedure	Oil sampling	FI
Propeller shaft control and monitoring system	I200 - Control and monitoring system documentation	Stern tube alarm system when arranged as a separate system	AP
AP = For approval; FI = For information ACO = As carried out; L = Local handling; R = On request; TA = Covered by type approval; VS = Vessel specific			

1.4.2 For general requirements to documentation, including definition of the Info codes, see Pt.1 Ch.3 Sec.2.

1.4.3 For a full definition of the documentation types, see Pt.1 Ch.3 Sec.3.

2 Design requirements

2.1 General

2.1.1 The stern tube bearing shall be oil lubricated.

2.1.2 Two (2) temperature sensors or one easily interchangeable sensor shall be fitted on the aft stern tube bearing. The sensor(s) shall be located in the bearing metal near the surface, in way of the area of highest load, which normally will be the bottom area (5 to 7 o'clock) in the aft third of the bearing. For shaft diameters > 300 mm additional temperature sensor for the forward bearing shall be fitted.

2.1.3 When one easily interchangeable sensor is fitted a spare sensor shall be kept onboard,

2.1.4 The setting of the stern tube high temperature alarm shall not to exceed 65°C unless a higher alarm set point has been accepted upon special consideration.

Guidance note:

It is recommended to arrange for two distinctive limits, the first limit set at 45°C to 60°C should initiate an alarm, the second limit set at 65° should initiate an automatic reduction of the engine load. Normally when the temperature rises above 80°C damage of white metal bearings is probable.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.5 The sealing rings in the stern tube sealing box shall be of a type which allows them to be replaced without shaft withdrawal or removal of the propeller. Chrome steel liner shall be arranged by a distance ring, allowing shifting of the track of the seals without the need to remove the shaft or the need to do machining.

2.1.6 An arrangement for bearing wear-down measurement shall be provided for. Hand operated gauges (typically poker gauge, top / down) are acceptable. The history of measurements must be documented in the files, as well as any change in position of chrome steel liner or measuring device.

2.1.7 The oil sampling points shall be arranged with a test cock and shall be fitted with a signboard. The sample location must be in next vicinity of the aft stern tube bearing, preferably in the pocket between aft bearing and seals.

2.1.8 It shall be possible to take oil samples under running conditions. Samples shall preferably be taken under similar operating conditions.

2.1.9 A grounding (earthing) device shall be installed.

2.2 Oil quality monitoring

2.2.1 Possible water content in the stern tube lubricating oil shall be monitored. The water in oil shall be checked either by a test kit provided onboard or by an accredited laboratory.

2.2.2 The water content is not to exceed 2% by volume. If the water content above 2% is detected appropriate action shall be taken.

2.3 Roller bearings arranged in the stern tube

2.3.1 Oil lubricated propeller shafts with roller bearings arranged in the stern tube shall comply with the following requirements:

a) Two (2) temperature sensors or one easily interchangeable sensor shall be fitted.

b) When one easily interchangeable sensor is fitted, a spare sensor shall be kept onboard,
c) The setting of the stern tube high temperature alarm shall not exceed 90°C unless a higher alarm set point has been accepted upon special consideration.
d) Vibration monitoring facilities shall be arranged for roller bearings. Handheld probes are not accepted; magnetic, glue, screw mountings or equivalent are compulsory.
e) Vibration signal shall be measured as velocity or acceleration. Integration from acceleration to velocity is allowed.
f) The vibration analysis equipment shall be able to detect fault signatures in the entire frequency range for the monitored bearing. A reference level under clearly defined operational conditions shall be established. The reference level shall be used as basis for establishing an alarm level.
g) The water content is not to exceed 0.5%.

2.4 Monitoring

2.4.1 Monitoring as required in Table 2 shall be arranged.

Table 2 Monitoring of shafting

	Gr 1 *Indication* *Alarm* *Load reduction*	*Gr 2* *Automatic start of standby pump with alarm*	*Gr 3* *Shut down with alarm*	*Comments*
Aft stern tube bearing, temperature	HA			See [2.1.2] and [2.3.1]

$Gr\,1$ = Common sensor for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction)
$Gr\,2$ = Sensor for automatic start of standby pump
$Gr\,3$ = Sensor for shut down
HA = Alarm for high value

2.4.2 The alarm shall either be provided by a separate sub-alarm system in accordance with Pt.4 Ch.9 or shall be part of the ship's main alarm system.

3 Testing

3.1 Application

3.1.1 Survey and testing shall be carried out according to Pt.7 Ch.1 Sec.6 [17] by the Society.

The temperature alarm shall be tested by the Society onboard the ship after the installation is completed, as well as the integrity of the second sensor, when fitted.

SECTION 6 BOILER MONITORING - BMON

1 General

1.1 Introduction

The additional class notation **BMON** is supplementary to the main class requirements regarding inspection of the water/steam side of the vessels boiler(s). The class notation **BMON** gives specific requirements which have to be followed to allow the chief engineer, at alternate surveys, to be responsible for carrying out and document inspection of the water/steam side of the vessels boiler(s). The documentation shall be presented to the attending surveyor who shall carry out the remaining scope of the boiler(s) survey.

1.2 Scope

The scope of additional class notation **BMON** verifies that a proper monitoring system for the vessels boiler(s) is in place, and thereby enable the chief engineer to carry out parts of the boiler survey. This section provides requirements for such a monitoring system which includes proper documentation and recordings, proper maintenance, and alarm systems for various parts of the boiler.

The scope also includes requirements of an initial survey, to verify that the monitoring system is in place.

1.3 Application

1.3.1 The additional class notation **BMON** may be granted for oil/gas fired boilers, exhaust gas boilers and steam generators at new building, or in connection with a boiler survey where it can be documented that the following requirements are met:

a) The boiler(s) shall have a sound structural integrity, and shall be examined and verified for the same.
b) The boiler(s) shall have no plugged tubes, deformations or other sign of damages, and shall be examined and verified for same.
c) The boiler(s) shall be free of soot, scales and sludge, and shall be examined and verified for the same.
d) Boiler water/feed water/condensate water monitoring and chemical treatment is implemented and conducted at least every 24 hours for trending purpose. Chemical treatment to provide a passive/ protective layer on the steam/water side shall be in use. Catalysed sodium sulphite does not provide a passive layer on the boiler steel.

   Other treatment than chemical treatment may be accepted only where it is substantiated that equivalent protection is accomplished.

   Quality of boiler water used during the new building stage of the ship shall also be maintained and documented in accordance with maker's recommended limits.
e) An onboard system to ensure that recording from boiler and feed water monitoring is kept updated and sent to vendor providing analysis of boiler water, condensate water and feed water, at regular intervals not exceeding 1 month. Results and recommendations from the analysis shall be followed up and kept onboard, ready and available for review by an attending surveyor.
f) Means for adding/dosing chemicals at appropriate places in the system, and at suitable intervals.
g) Means for taking representative samples from appropriate sampling points, at suitable temperature (e.g. sample cooler installed) has been established.
h) Means for keeping the condensate water/feed water at recommended temperature in order to minimise oxygen content (e.g. normally well above 80°C. in non-pressurised feed water system, feed water tank, observation tank) has been established. The higher temperature, the better oxygen removal is achieved, temperatures as high as 90 to 95°C is advisable in this respect, bearing in mind possible pump design limitations.
i) Means for detecting and early warning of salt water contamination has been established.

j) Means for detecting oil in the condensate water/feed water has been established and connected to the alarm system.
k) Means for preventing oil contamination from entering the boiler(s) has been established.
l) Internal inspection by the chief engineer of the water side of the boiler shall be conducted as a minimum once per year. Specific job in the onboard maintenance system shall be implemented.
m) Furnace/fire side shall be inspected by the chief engineer every 6 months as a minimum. Specific job in the onboard maintenance system shall be implemented.
n) Maintenance of the boiler, burner and control systems as recommended by the makers, as a minimum, is implemented in the onboard maintenance system.
o) Burner and burner control system, is serviced by competent personnel once a year.
p) In case of installations of two or more boilers, where boiler(s) are left idle, stand by or in wet lay up for a prolonged period, procedures for boiler water monitoring shall be implemented and followed up accordingly for the idle/stand by boiler(s).
q) For boilers/steam generators where visual inspection of the water steam side is not possible due to design limitations, a hydraulic pressure test of 1.5 times design pressure shall substitute the visual examination. Visual inspection may include effective use of mirrors, closed circuit television, borescope, camera or equivalent.
r) Provisions to monitor exhaust gas differential pressure on exhaust gas boilers shall be provided. U-tube manometer is an acceptable means of monitoring exhaust gas differential pressure.

1.4 Documentation requirements

1.4.1 Documentation shall be submitted as required by Table 1.

Table 1 Documentation requirements

Object	*Documentation type*	*Additional description*	*Info*
Auxiliary steam system	C020 - Assembly or arrangement drawing	Including salinometers, oil content meters in the feedwater/ condensate systems, sampling points and routines for taking samples.	AP
	C020 - Assembly or arrangement drawing	Provisions to monitor exhaust gas differential pressure (for exhaust gas boilers only).	AP
	Z163 - Maintenance manual	Boiler water, feed water and condensate water monitoring and treatment including follow up and reporting procedures.	AP
	Z163 - Maintenance manual	Applicable maintenance jobs in the onboard maintenance system, including level of reporting.	AP
	Z163 - Maintenance manual	Plan for monitoring of boiler water and conservation during boiler idling or stand by.	FI
Propulsion steam system	C020 - Assembly or arrangement drawing	Including salinometers, oil content meters in the feedwater/ condensate systems, sampling points and routines for taking samples.	AP
	Z163 - Maintenance manual	Boiler water, feed water and condensate water monitoring and treatment including follow up and reporting procedures.	AP
	Z163 - Maintenance manual	Applicable maintenance jobs in the on board maintenance system, including level of reporting.	AP
	Z163 - Maintenance manual	Plan for monitoring of boiler water and conservation during boiler idling or stand by.	FI

Object	Documentation type	Additional description	Info
AP = For approval; FI = For information ACO = As carried out; L = Local handling; R = On request; TA = Covered by type approval; VS = Vessel specific			

For general requirements for documentation, including definition of the info codes, see Pt.1 Ch.3 Sec.2.
For a full definition of the documentation types, see Pt.1 Ch.3 Sec.3.

1.5 Initial survey

1.5.1 The survey shall include:

— a complete boiler survey
— verification that the boiler is free of plugged tubes, deformations or other sign of damages
— verification that the boiler is free of soot, scales and sludge
— verification of the boiler water/feed water/condensate water monitoring and treatment is implemented and in use
— verification of applicable maintenance jobs in the onboard maintenance system.

1.5.2 On a case by case basis the Society may consider equivalent methods of verifying the condition of the boiler(s) as required by the initial survey for **BMON** assignment in [1.3.1] provided:

a) The equivalent methods considered shall be capable of verifying a satisfactory condition of the boiler(s) detailed in [1.3.1] prior to assignment of **BMON** and shall as a minimum include:
   — a boiler survey to the satisfaction of the Society in conjunction with review of photographic/video evidence of condition of steam and water side of the boiler
   — review of documented history of internal inspections, repair and maintenance
   — review of boiler water management records and comments from service providers.

b) Historic evidence of satisfactory boiler water treatment capable of providing a passive/protective layer is submitted.

c) Statement from the ship's chief engineer confirms that the boiler is free of defects.

DNV GL

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SAFER, SMARTER, GREENER